EMBJ.ORG FOR YOUNG DOCTORS

EUROMEDITERRANEAN BIOMEDICAL JOURNAL
2017,12 (27) 130–134
(*FORMERLY: CAPSULA EBURNEA*)

Technical report

BRACHIAL PLEXUS: CONSIDERATIONS AFTER A CADAVERIC STUDY

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ARTICLE INFO

Article history:
Received 15 June 2017
Revised 31 July 2017
Accepted 09 September 2017

Keywords:
Cadaveric study, brachial plexus, dissection course.

ABSTRACT

During the summer of 2016, a group of students from the University of Palermo attending the second year of medicine school took part in a four week course of Whole Cadaveric Dissection at the University of Malta. Within this project, we students worked on a male cadaver by using a surgical kit, taking care to record everything with pictures and videos. In this way, every structure was isolated and studied in comparison with the anatomic atlas' pictures. The aim of this article is to show the dissection method of the brachial plexus that we used. We started removing cutis and subcutis, then we identified the muscles' origin and insertion; after isolating vascular-nervous structures, we finally exposed nerves, cords, trunks and roots of brachial plexus by using blunt dissection method.

1. Introduction

The anatomical dissection is an indispensable resource for the study and comprehension of human anatomy. Especially for those young students who have just begun their training in the world of medicine (1-2). There is a huge benefit from cadaveric dissection. Learning dissection techniques allows to better understand the morphology and the mutual relations of anatomic structures and sectionplanes (3). The University of Palermo (Italy) has faced this problem by concluding an agreement with the University of Malta. So every year, thanks to the cooperation between professor Francesco Cappello (Department of Experimental Biomedicine and Clinical Neuroscience, University of Palermo) and professor Cristoforo Pomara (Department of Anatomy, School of Medicine, University of Malta, Msida), ten students have the opportunity to attend a four week stage of Whole Cadaveric Dissection at the University of Malta under the supervision of professor Pomara. These student, chosen on the basis of merit and interest, can master the study of regional anatomy. Furthermore, thanks to the possibility given to us by EuroMediterranean Biomedical Journal, we can show our interesting experience to scientific community (4, 5). This article focuses its attention on the brachial plexus dissection from the anatomic description with the identification of each component, to the technical aspects. The brachial plexus is one of the most complex anatomical region and it is very difficult for the students to learn about it using only the common textbooks and atlas (6-11). Hence, it was a great opportunity to improve our knowledge on this topic. Nowadays the anatomic dissection is not a common practice in the Italian university. There is no regulation about expressing the will to donate the

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DOI: 10.3269/1970-5492.2017.12.27
 ISSN: 2279-7165 - Available on-line at www.embj.org

ones body to science. Moreover, other problems are related to the costs of the Sectory rooms that are too expensive for the universitary Departments. For this reason, Italian medical students need often to travel abroad to learn how to dissect.

2. Material and methods

For our study on a male cadaver we used the dissection hall of the Department of Anatomy of the University of Malta, School of Medicine.
The corps was embalmed with a solution composed by 99% of phenoxyethanol and 1% of formalin, and it was maintained at a temperature between 2 - 4°C. The process of the embalming starts from the incision of the femoral artery and femoral vein, situated in the triangle of the Scarp; salt water was pumped into the femoral artery using a catheter and the blood went out from another catheter, inserted in the femoral vein. As soon as the salt water came out instead of blood, we stopped pumping the salt water and started pumping the solution of phenoxyethanol and formalin for twenty minutes. The artery and the vein were closed and the skin sutured.
A basic surgical kit composed of a scalpel handle, n.4 for blades 20-24, anatomy forceps, surgery forceps, a scissors straight blunt/sharp, a klemmer forceps and kocher forceps was used for the dissection.
Blunt dissection method was used for fasciae and to isolate vascular-nervous structures from the fat; we used the scalpel for cutis, subcutis, muscles and tendons.
Before the dissection we first studied the structures of the different regions on the anatomical and cadaver's atlas and on the Forensic Autopsy, a Handbook and Atlas. After presenting a working plan, we started the dissection and we made a comparative study about the differences between the anatomical notions we had and the actual data we saw.

3. Results and discussion

Upper limb (left): in the Figure 1, the roots of brachial plexus are shown. Furthermore, the dislocated clavicle can be seen. The clavicle dislocation is required in order to work in this region. In the foreground of the picture the sternal articular face of the clavicle is evident.

Figure 1 - 1) Cervical root five, 2) Cervical root six, 3) Cervical root seven, 4) Cervical root eight, 5) Thoracic root one

Upper limb (left): in the Figure 2, the three trunks of brachial plexus and the origins of the roots are shown.
Upper limb (right):in the Figure 3,the cords and the terminal nerves of brachial plexus are highlighted.

Figure 2 - 1) Upper trunk, 2) Middle trunk, 3) Lower trunk

Figure 3 - 1) Lateral cord, 2) Musculocutaneous nerve, 3) Median nerve, 4) Medial cord, 5) Ulnar nerve

Upper limb (right):in the Figure 4, the "M" structure is shown. It is created by the terminal nerve of brachial plexus which is shown in all atlases.
Upper limb (right):in the Figure 5, the cords and the terminal nerve of brachial plexus are visible.
Upper limb (right):the Figure 6 shows the brachial plexus and the relationship between the subclavian artery and the brachial plexus itself. The Suprascapular nerve canals to be noticed.

Figure 4 - 1) Musculocutaneous nerve, 2) Median nerve, 3) Ulnar nerve, 4) Lateral cord

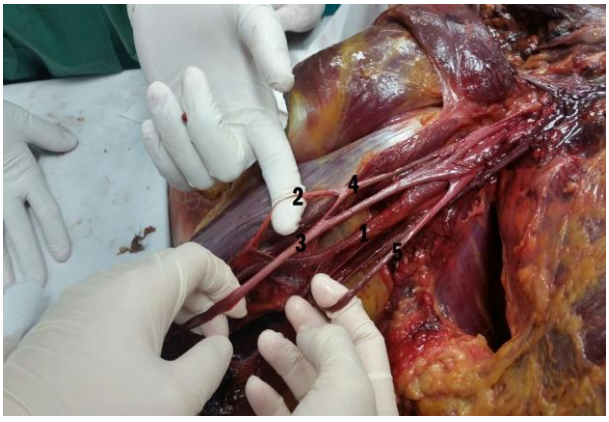

Figure 5 - 1) Posterior cord, 2) Musculocutaneous nerve, 3) Median nerve, 4) Lateral cord, 5) Medial cord

Figure 6 - 1) Subclavian artery, 2) Cervical root eight and thoracic root one, 3) Cervical root seven, 4) Cervical root six, 5) Cervical root five, 6) Suprascapular nerve

4. Discussion

We first made a calyx shaped incision on the chest from the clavicular acromion down to the xiphoid process and up to the other clavicular acromion. We detached the cutaneous and subcutaneous layers in order to expose the pectoralis fascia. We incised the upper limb and detached subcutis as well to expose the pectoralis major insertionregion. Then we cleaned the pectoralis major, on its clavicular, sternal, and sternocostal insertions incising up to the posterior axillary line so we could reflect the muscle laterally on its humeral insertion.

At this point pectoralis minor is revealed. We cleaned this muscle by tracting and dissecting until we reflected it to the coracoid process.Then we disarticulated the sternoclavicular joints. To identify the articular heads, we moved the corresponding shoulder while incising the articular line. Now the axillary and brachial plexus regions needed to be cleaned from fatty and lymphatic tissues. To facilitate this cleaning operation, we kept the arm abducted.

Once we had this region cleaned, we orientated ourselves using an axillary artery as anatomic landmark and above all we started identifying the “M” structure composed of three of the five terminal branches: the musculocutaneous nerve that lead us to the coracobrachialis muscle, the median nerve and the ulnar nerve. Following them up we identified the axillary artery; laterally to it, the lateral cord and medially the medial cord are highlighted.

We also worked backwards to identify the superior, middle and inferior branches. The posterior cord was like the upper, middle and lower subscapular nerves are revealed by pulling the “M” structure up and away.

We used the interscalenic gap as a guide to superior, middle and inferior trunks and from them we started to clean the C5, C6, C7, C8 and T1 roots.

Once every single root had been cleaned the whole brachial plexus was dissectioned. To isolate each single trunk, cord and terminal branch we used a technique called blunt dissection: It consists of using the blunt scissors or fingers to carefully separate anatomical structures from connective tissue.

The brachial plexus is a somatic nerve plexus composed of intercommunications among the ventral branches of the lower 4 cervical nerves (C5-C8) and the first thoracic nerve (T1). The brachial plexus is divided into five parts: roots, trunks, divisions, cords and branches. There are no functional differences between these divisions – this is a simple anatomical terminology.

The fifth cervical nerve and the first thoracic nerve may receive side branches respectively from C4 and T2. This contribution from C4 and T2 is variable and it may change in contracting anastomoses. With its countless nervous branches, the brachial plexus provides the motor and sensory innervation of a part of the chest, the shoulder, the arm and the hand.

The brachial plexus does not innervate the trapezius muscle nor the skin near the axillary area. The innervation of the trapezius muscle depends on to the accessory nerve (a cranial nerve), while the innervation of the skin near the axilla leads to the intercostobrachial nerve.

The most common anatomical variation of brachial plexus is structured in the following way: the union of C5 and C6 roots form the superior trunk on the lateral border of scalenus medius; C8 and T1 roots form the lower trunk, behind the scalenus anterior; C7 becomes therefore the middle trunk. The three trunks lay laterally, above or behind the clavicle, each one forks in an anterior and posterior division. The two anterior divisions of the middle and superior trunk form the lateral cord, laterally to the axillary artery. The anterior division of the lower trunk proceeds from

behind and then medially the axillary artery, and forms the middleord. The posterior division of each trunk forms the posterior cord, located at first above and then posteriorly to the axillary artery. The terminal branches of the brachial plexus result from three cords; they consist of five nerves: musculocutaneous nerve, ulnar nerve, median nerve, radial nerve and axillary nerve. The musculocutaneous nerve is in continuity with the lateral cord and its fibers derive from the roots C5, C6 and C7; it innervates the coracobrachialis muscle, the brachial muscle and the brachial biceps muscle; the musculocutaneous nerve also innervate a forearm cutaneous portion. This nerve is the most lateral of the brachial plexus. It originates attached to the subscapularis muscle and reaches the anterior compartment of the arm piercing the coracobrachialis muscle; it continues between coracobrachialis and biceps muscles; then it crosses the gap between the brachial biceps muscle and brachioradialis muscle. During its course in the arm it splits into muscular branches. Anteriorly, at the level of the bend of the elbow it deepens under the subcutaneous layer becoming the forearm lateral cutaneous nerve. It is divided into an anterior and a posterior branch and it is distributed to the side of the forearm skin.

The ulnar nerve originates from the middle cord and groups the roots from C8 to T1. It innervates the flexor carpi ulnaris, part of the deep flexor muscles of the fingers, theextrinsic muscles of the hand (except the thenar muscles and the two lateral lumbrical muscles). The ulnar nerve also innervate the skin of the medial side of the hand, the palmar skin of the first three fingers and a half (thumb, index, middle and half ring finger) and the dorsal skin of the two fingers and a half (thumb, index and half of middle). From the axillary region it goes along with the median nerve and brachial artery in the anterior-medial loggia of the arm. Then, around the medial epicondyle posteriorly, it comes into contact with the medial margin of the triceps tendon. It enters anterior-medially to the forearm, alongside the ulnar artery to the bone pisiform, here it divides into its terminal branches (superficial and deep palmar branch of thehand).

The median nerve derives, in part, from the middle cord (includes the roots C5, C6 and C7) and, in part, from the lateral cord (includes the C8 and T1 roots). It originates from two roots, the medial and lateral secondary trunks which come together to form a "V" in front of the axillary artery. Along the anterior surface of the arm together with the humeral vessels, it continues in the forearm passing under the pronator teres muscle continuing along the midline. At the wrist it goes into the carpal canal then into the palm of the hand in its terminal branches. It innervates the anterior forearm muscles and the intrinsic muscles of the hand with the ulnar nerve; then it innervates the lateral palmar skin and the skin of the distal phalanges of the five fingers.

The radial nerve is in continuity with the posterior cord and contains fibers from all the roots of the brachial plexus. It innervates the triceps brachii muscle, the brachioradialis muscle, the anconeus muscle, the forearm extensor muscle and the brachioradialis muscle. Through its terminal branches the radial nerve innervates: the skin of the back portion of the arm, the skin of the lateral portion of the arm, the skin of the back and central region of the forearm, and, finally, the skin of the dorsal surface of the thumb, index, middle and half ring finger. The radial nerve originates in axilla, it goes towards the posterior loggia of the arm with the deep humeral artery; passing under the teres major muscle it meets the radial groove on the posterior surface of the humerus between the medial and lateral head of the triceps muscle and, at the elbow, it goes anteriorly passing between the brachial muscle and brachioradialis muscle. After that, it splits into its terminal branches: deep radial nerve and superficial radial nerve.

Finally, the axillary nerve is in continuity with part of the posterior cord, to be precisethe roots comprising C5 and C6. It innervates a small part of the deltoid muscle and the teres minor muscle and transmits sensory information to the articulation of the shoulder. From the posterior secondary trunk it goes into the axilla posteriorly and reaches the quadrangle space formed by: teres minor muscle, teres major muscle, long head of the triceps muscle and surgical neck of the humerus.

The brachial plexus has other nerve branches; these are called collateral branches and they have their origin in the brachial plexus preceding the cord or through one of the terminal branches. They can be divided into dorsal and ventral branches; the ventral branches are:

- Subclavian nerve (C5-C6): it originates from the superior trunk and innervate the subclavian muscle; it anastomoses with the phrenicnerve;
- Lateral pectoral nerve (C5-C7): it originates from the lateral cord then passes medially and it divides at the level of the deep surface of the pectoralis major;
- Pectoralis minor nerve(C8-T1): it originates from the middle cord, innervates the pectoralis minor and anastomoses with the nerve of the pectoralis major;
- Suprascapular nerve (C5-C6): it originates from the upper trunk, goes up to the top of the scapula bladeedge,it overrides the middle scalene muscle and goes under the trapezius muscle. It also innervate the supraspinatus muscle.

The dorsal branches are:

- Dorsal nerve of the scapula (C4-C6): it goes to the medial angle of the scapula. It innervates the levator scapula muscle and the rhomboid muscles;
- Long thoracic nerve (C5-C7): it passes posterior to the roots of the primary trunks and then innervates the serratus major muscle;
- Upper and lower subscapular nerves (C5-C6): they originate from the posterior cord to innervate the upper subscapularis muscle, the lower subscapularis muscle and the teres major muscle.
- Thoracodorsal nerve (C6-C8): it originates from the posterior cord and innervate the latissimus dorsimuscle.

5. Conclusions

Practicing on a real cadaver is totally different from what we would have ever expected studying in books and atlas (6-11). In fact we found it extremely difficult to work on a real corpse, especially for such a complex part of the anatomy like the brachial plexus. Furthermore, while in books or atlases the brachial plexus is perfectly divided from other structures, like the axillary artery, in reality its separation is a result of difficult manual techniques. However, the actual identification was only the last part of our work, because it had been anticipated by a long process of isolation from its surrounding connective tissue. Therefore for all of us this was an experience of perfect union between theoretical and practical activities, similarly to the previous heart dissection course conducted likewise at the University of Malta during the same period (12).

6. Acknowledgements

We would like to thank the University of Malta for welcoming us and giving us this extraordinary study opportunity. Our special thanks go to professor Francesco Cappello whose personal availability and professional support were essential in the carrying out of our project.

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